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CLIMATE CHANGE AND THE CGIAR

TAC's Progress Report to the CGIAR[1]

1. Introduction

The aim of this report is to provide an initial overview of selected climate change (CC) issues as they relate to the CGIAR. Firstly it focuses on the following aspects:

- Status of CC science and its main actors;
- Uncertainties in CC impacts and projections;
- Climate, variability and vulnerability of ecosystems to CC;
- Strategies for adaptation and mitigation.

Subsequently the report reviews recent CC developments within the CGIAR and outlines a number of recommendations to be considered by TAC and the CGIAR for further action. It is important to note that this is a progress report only, since climate change is a subject worthy of greater attention and further initiatives, possibly with external consultation.

2. The science of climate change and its actors

Global warming is a fact. There is scientific evidence that the earth's surface temperature has been increasing over the last 40-50 years. By the end of 1998, the warmest year on record since 1860, the global surface temperature was about 0.6°C higher than around 1990. Based on statistical studies of plant phenology in Southern Germany and Canada, recent reports confirm that spring comes earlier and autumn later in northern latitudes (by about a week over a 40 year period).

Can the change be attributed to human influence on climate? The effect of human-made greenhouse gases led the Intergovernmental Panel on Climate Change (IPCC), in its second Impact Assessment Report in 1995, to state that even though *our ability to quantify the human influence on climate is limited ... the balance of evidence suggests that there is a discernible human influence on global climate*. It appears from what we know now that the

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[1] TAC gratefully acknowledges the contributions of the members of FAO's interdepartmental group on Climate Change and Climate Variability, in particular those of its Secretary Dr R. Gommes

third IPCC Report, due in 2001, will strengthen this implication. A number of reports suggest that human activities related to farming, livestock and forests contribute to one fourth of the global warming potential.

Current Research Activities. A positive aspect of CC concern is the extraordinary expansion in recent years of climate-related research. Areas of interest to the CGIAR include:

(a) Simulation modeling of the global climate and downscaling to regions.
(b) Impact assessment on various ecosystems, specifically on agriculture, forests, fisheries and food production. (This would be the area of current research activities that is least developed.)
(c) Adaptation and mitigation measures.

a) Simulation modeling of the global climate and downscaling to regions

Climate models, based on general circulation models (GCM) of atmosphere-ocean systems, are improving. Several models being developed in the USA, UK, Germany, Canada, Japan, etc., reproduce global warming already experienced reasonably accurately, thereby providing some reliability for future projections. The improved models have incorporated new components of atmospheric chemistry such as the sulfur cycle and in order to run, require some of the world's largest computers.

Nevertheless, new issues are constantly appearing, such as the stability of ocean circulation and its potential impacts, which require modifications in the models. There are still a number of feedback effects, which produce a wide range of responses in existing models at the global scale. Most GCMs are equilibrium-type models and do not take into account weather variability or the fact that changes take place gradually. More realistic, transient models are being developed but do not yet yield accurate predictions; if they did, we could have reliable seasonal forecasts right now!

Climate models are also being used to develop projections at the regional level by adding weather (i.e., variability), as well as the effect of topography, vegetation etc. As GCMs improve, the scale at which regional projections can be made will increase and climate scenarios will be produced within a spatial resolution of about 250 km.

b) Impact assessment on various ecosystems, specifically on agriculture, forests, fisheries and food production

There is ongoing impact assessment research in three major areas: modeling agricultural production under various climate scenarios; field experiments on the effects of increased CO_2; and analysis of past ecosystem performance in relation to increased CO_2.

The impact of CC on world food production is modeled by using crop models in conjunction with national agricultural and world trade models. The positive effects of increased CO_2 on crop productivity are being measured in the field in free-air CO_2 enrichment (FACE) experiments, under more realistic conditions than previous research in growth and open-top chambers. Crops studied in the FACE experiments include wheat, cotton, sorghum, rice, forage crops and pastures. Most of the work is carried out in developed countries. Plans to carry out FACE experiments on natural ecosystems such as the chaparral, loblolly pine, desert species and in a Panama forest are underway. Finally, several recent analyses of historical crop production records relative to greater CO_2 levels are providing additional insight into expected crop response to CC.

c) Adaptation and mitigation measures

Many CC adaptation measures can be sourced from past and current research on improving productivity and natural resource management. These are discussed later. There is also emphasis on carbon sequestration in plants and soils as a mitigation measure and on reducing methane and nitrous oxide emissions by using agroecosystems.

With respect to research actors, the programmes are on a very large scale. As an example, the current GCM developed at the Hadley Center in the UK employs more than 100 scientists and engineers. There is also significant coordination of the research done at various centres. The International Geosphere-Biosphere Programme (IGBP) coordinates research on global change. Operating on an annual budget of more than US$ 1 billion, IGBP represents the efforts of many scientists, mainly in the developed world. IGBP has five core projects, one of which (the Global Change and Terrestrial Ecosystem, GCTE) is the most relevant to the CGIAR, although other programmes such as the one on Land Use and Cover Changes (LUCC) are equally important.

3. Uncertainties in climate change impacts and projections

On climate change at the global scale

GMC predictions indicate further warming of the earth by about 2-3° C over the next 100 years if nothing is done in the meantime to reduce greenhouse gas emissions. There is also general agreement on the increase in global precipitation and on the rise in ocean levels due to thermal expansion and ice melting.

Regional Scale

For several years, the notion has prevailed that global warming was neutral or favourable in temperate latitudes and disadvantageous for the tropics and sub-tropics. The discrepancies and uncertainties observed in the regional predictions obtained by GCMs do not permit

more accurate predictions today. Very recent research is providing more robust and consistent regional models; however these models still do not encompass features such as changes in pest, diseases and weeds, or many of the physiological, agronomic, socioeconomic and cultural adaptations that may occur during CC.

While regional predictions may remain speculative for some time, it will be important to observe coincidental patterns and predictions in areas where the CGIAR operates. At present, regional projections suggest that Africa might be the continent worst hit by CC, while other areas in the subtropics of Asia and Latin America could also be badly affected.

Impact on food production

Simulated impacts of CC on world food production also remain uncertain and speculative. When GCM scenarios are used for simulation, together with the positive effects of increased CO_2 and adaptation measures, global projections only fluctuate by a few percent (up or down) after 50 years (compared to the annual 1-2% yield increases experienced at present).

Regional projections may be considerably more dramatic in some areas but again, with even greater uncertainty. This particular research topic suffers from: a) a current slowdown in the progress of crop simulation models that do not yet predict yields accurately, particularly under limiting water/nutrient and biotic stress conditions; and b) a decline in the collection of pertinent agronomic field data to calibrate, validate and test such crop models in different environments.

Effects of increased CO_2 on primary production

Early research into CO_2 fertilization effects on plant productivity and water use efficiency (WUE), conducted in growth chambers, led to projections of significant increases in yield (30-80%) and similar effects in WUE in response to a doubling of CO_2, particularly in C_3 crop plants. So far, FACE experiments have reduced those expectations to about a 15% yield increase in the case of wheat. Such a positive response is more or less sustained in the case of moderate water and nitrogen stress (B. Kimball, pers. comm.). Interactions with other biotic and abiotic stresses under relevant field conditions still remain speculative. Water use rates from smooth crop surfaces (wheat, rice) should not decrease much under elevated CO_2 despite the partial stomatal closure activated by greater CO_2. Thus, the most recent research results suggest that determinate crops will exhibit modest yield increases under both optimal and suboptimal conditions and will have water use rates similar to those experienced at present (the warming effects on evapotranspiration would be more or less compensated by the increased WUE effects). Indeterminate crops such as cotton and forest trees appear to respond more positively to increased CO_2 but more experimental information is required to quantify the net crop and water productivity gains.

Yield trends in response to increased CO_2.

CO_2 increased from about 280 ppm in 1800 to about 370 ppm today. Several analyses have been carried out to assess the impact of this increase on crop productivity, concluding that so far greater CO_2 levels make a small contribution to yield increases. Such analyses tend to support the evidence obtained from the FACE experiments described above.

4. Climate, variability and vulnerability of ecosystems to climate change

Climate change concerns have generated substantial advances in climatology, which may prove beneficial in improving climate-agriculture interactions. Agriculturalists could gain by a shift in thinking from considering climate a hazard to considering it as a resource that can be managed. In this respect, it is important to draw the CGIAR's attention to the continuous deterioration of weather station networks in many developing countries, particularly in Africa and parts of Asia. At a time that may prove critical for CC characterization, lack of funding means that data collection is being discontinued in many places, particularly in rural areas. Without adequate weather records, site-specific strategies to cope with CC cannot be developed.

Together with advances in climatology and meteorology, the attention that the CC phenomenon is receiving worldwide should be used to make agriculture more stable and sustainable. This would be possible if reliable tools for assessing such ecosystem properties became available.

Hitherto we have discussed CC as the outcome of global warming and associated changes in precipitation. A change from one climate to another could take place in a given location: for example, the climate in Milan, Italy, might shift to that of Florence and the future climate there might be very similar to the current climate in Rome. In other words, there would be no new climates but just shifts in current climates. However, a completely different picture would emerge if the associated climate variability were also to change in response to CC.

No scientific evidence is yet available to suggest that CC will induce an increase in weather variability above current levels. There are suggestions that rainfall variability might increase as a result of enhanced evaporation and precipitation, but the subject is still the topic of scientific debate. It is true that the last El Niño event was the strongest of the century and research is underway to link El Niño events to CC. So far, there is more evidence that the recent enhancement of El Niño events is consistent with the rise in air temperatures.

Greater weather variability would make many ecosystems more vulnerable. Vulnerability is understood here as the potential for negative impacts arising from CC. Agricultural ecosystems are probably more vulnerable to increased weather variability than to a gradual change in climate. Higher variability could increase the frequency of extreme events or the occurrence of sequences of unfavourable years, leading to more instability and threatening sustainability. This is one of the most critical points of CC-related research to monitor in the future.

The assessment of vulnerability to CC is linked to quality of the projections, which, as we have seen, are still characterized by high uncertainty. Regardless of projections, the point to stress here is that the poorer regions and the poorest individuals would be the most vulnerable to CC just as they are to other changes in economic, political and natural environments.

Poor communities in many regions have difficulty in adapting to even a small shift in weather. The CGIAR should, therefore, think about anticipating CC and considering measures to reduce its impact on the poor, despite the current degree of uncertainty regarding its effects.

5. Strategies of adaptation and mitigation

Current emission levels of greenhouse gases are contributing to what could become a global problem. The precautionary principle argues for attention now. As some greenhouse gases reside in the atmosphere for quite a long time (100-150 years), the effects from the past will last for many decades even if the current situation is reversed. In a general sense, response options are available to face climate change: reduce net emissions (mitigation) and adapt to changes.

Agriculture is primarily about adapting to climate. For many centuries, farmers have been pushing environmental limits where they grow their crops. Therefore, they have many weapons available in the arsenal of adaptation measures to CC. With respect to the recent past, it should be pointed out that the CGIAR has been a major provider to that arsenal.

At any rate, adaptation of agriculture to CC will assume many dimensions; innovations based on new science and technology will have to be combined with adaptive measures in the socioeconomic, institutional, and cultural/anthropological areas. Indeed, the capacity for adapting to CC will probably be more related to the successful implementation of such adaptive measures than to the scientific innovations.

The idea here is that we already have enough germplasm diversity in major crops to grow them in vastly different climates. Maize can be grown in Oaxaca but also in Canada, Zaire or Denmark; the same is true for the other major staples. There is even potential to expand further the current limits of adaptation by using biotechnology, an option that should

concentrate on increasing the capacity to adjust to high temperatures. For a well-educated farmer with access to information, shifting species or cultivars in response to CC would be relatively easy and could be done rapidly. The challenge facing the CGIAR is what can be done to help the poor farmer to adjust to CC more quickly?

Adapting to greater climate variability would be more difficult, but there is significant potential if seasonal forecasting became more reliable. Even though short-term forecasting in the tropics is still very difficult, the good news is that seasonal forecasts are improving (R. Gommes, FAO; pers. comm.). Thus, countries important to the CGIAR would have the option of managing their farming systems with less uncertainty by carrying out what is termed response farming.

In response farming, current weather is monitored (as it "happens") and this forms the basis for farm-level decision making relying on the comparison of weather with decision tables. Response farming can be enhanced and expanded to use models, satellite imagery, and to include forecasts. For a predicted drought, inputs are decreased from average levels while they expand if the prediction is for a good year. Successful examples of response farming already exist in Australia to the El Niño Southern Oscillation (ENSO) predictions. There have also been some good attempts in Kenya in the past and there are now simple approaches of this sort underway in Mali. Extension education efforts, perhaps based on recent advances in electronic communications, would be critical to expanding the use of response farming in many regions. Certainly, it is a very promising approach to reducing the impact of weather variability.

The list of mitigation measures for gas emissions in agriculture is long, but it is important that the measures proposed from agriculture and forestry would actually help reduce the problem. Carbon sequestration in forests and soils is a very popular research topic and there are many initiatives underway outside the CGIAR that will hopefully provide some definitive results on the potential of the various options currently under investigation. Carbon substitution by growing crops and trees for energy is an increasingly important option, which should be assessed within an overall food security and poverty perspective. The Brazilian experience offers an example for careful study.

The central issue in mitigation is that land use change and deforestation have been and could be the major contributors to CC from the agricultural sector. Greater future demand for food, together with pressures on agricultural land from urbanization, could force mankind to extend agricultural lands beyond current levels, the consequences being increased deforestation, soil carbon losses and negative impact on CC. While not a very popular view, intensification of sustainable agricultural production is a major objective linked to mitigation efforts.

6. Current status of CC in the CGIAR

Recent activities include the following:

- The Withey Report to TAC (an inventory of activities within the CGIAR, listing the research projects dealing with CC. It can be concluded that most or all of the centres are doing work related to CC.)
- The Intercentre Group on Climate Change (IGCC), set up in 1998, which actively seeks support for CC research activities.
- The initial activities of the IGCC, specifically funded to study CC, have focused on evaluating what the CGIAR has done and on proposing CC research requirements to the CGIAR System.

7. Options and recommendations for consideration

Global climate change is a prominent theme worldwide. The CGIAR has already made significant contributions concerning adaptation and mitigation to climate change, for example, through yield and productivity increases that have reduced the pressure on forests and on marginal lands. Furthermore, much of the CGIAR's work on poverty opens up further options for adaptation to climate change. Finally, earlier discussion emphasized that CGIAR concern for the poor is in itself enough to bring attention to climate change.

Against this background, what can the CGIAR do to contribute more to global CC efforts? This question could be looked at from two perspectives: first, from the current objectives of the CGIAR System; and second. where these objectives have been expanded to include CC along with poverty and natural resources conservation. Let us first examine the former.

Successful CGIAR efforts to reduce poverty will be enough to reduce the impact of CC on the poor since their stronger progeny will be better placed to deal with the effects of CC.

In order to become more efficient, the CGIAR is pursuing a sharper delineation of the locus and level of poverty and the circumstances of poor people, including the biophysical characteristics of the regions in which they live. Together with advances in modeling, both of crops and CC impact, this delineation will enable the CGIAR to provide ever more accurate information about those commodities and varieties which best suit the evolving climate/region patterns induced by CC thus making adjustment easier for producers.
One of the CGIAR's most important contributions is its research into the production environments, which provides benchmark data necessary to characterize CC. The CGIAR could supply this data to others involved in CC research, e.g., the IGBP, in order to validate models and make projections, thereby making their work more effective. In addition, such investments could help overcome some of the difficulties arising from the decrease in data gathering efforts in many developing countries noted earlier.

In pursuing improved technologies and policies, many, if not all CGIAR activities enhance capacity to adapt to CC. As long as there is no change in CGIAR goals, that work will continue. The CC dimension must be added to all work with clear implications for adaptation and mitigation. In this respect, perhaps inadequate attention has been given to CGIAR efforts to develop more robust plants able to tolerate the weather swings that some people predict will be heightened by CC.

Expanding CGIAR objectives to include specific attention to CC mitigation would of course draw resources away from current activities; there would appear, therefore, to be no strong justification for such a change at present. Considerations limiting such support include: the annual expenditure of more than US$1 billion (over three times the CGIAR's entire annual budget) on the topic in major research laboratories around the world; and the prognosis that future generations will be better off than the present one and thus able to accommodate the consequences of CC, with less demand on the research resources currently focused on the poor. However, the developing technologies and policies for the poor should obviously take into account the likely consequences for CC.

In the immediate future, given the concern for emerging CC issues, representatives from the CGIAR, the ICWG/CC, TAC, and other interested parties, especially those involved in CC research, should organize a workshop with the aim of ascertaining the current state of knowledge and identifying arenas in which the CGIAR could best complement work on critical subjects with a relatively restricted budget.